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The Evaluation of Field Bean (Phaseolus vulgaris L.) as an Alternative Grain and Seed Production Crop for Irrigated Regions of South-central Saskatchewan

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FINAL REPORT
Project R-86-03-0045
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1.0 REPORT SUMMARY

1.1 Abstract

The project goal was to generate agronomic information for irrigated production recommendations for dry bean, a potential new specialty crop for south-central Saskatchewan. Results showed that adapted dry bean varieties are available, especially in the pinto market class. Pinto bean should be seeded in the fourth week of May at 30 seeds per square meter in 18-24" rows. Sclerotinia stem rot is the major production problem. The crop can be left standing and direct combined at 16-18% seed moisture. A production guide is being prepared for irrigation farmers in the Lake Diefenbaker region.

1.2 Summary

The Lake Diefenbaker area in south-central Saskatchewan is one of the few regions in the province with a growing season suitable for dry bean production. In the late 1970s, an attempt was made to establish a dry bean industry. This effort failed because the production system involved row cropping and because there were few local marketing opportunities. Since then, the Saskatchewan pulse industry has expanded around lentil and pea production. This project was initiated with the overall goal of developing a dry bean industry by taking advantage of the successful production technology and marketing system developed for the lentil crop.

The specific objectives of the research project were to identify varieties of dry bean for Saskatchewan conditions and to investigate suitable agronomic practices for production of dry bean. This included determining suitable seeding date, seeding rate, row spacing, harvest date and method of harvest for dry bean. The project was located at the Saskatchewan Irrigation Development Centre at Outlook, and ran for three summers beginning in 1986.

Variety testing for the past three years showed that varieties of suitable maturity were available for pinto, pink, red mexican, great northern and navy beans. The pinto class in particular has several varieties with suitable yield and maturity for the Lake Diefenbaker area. In North America, about 40% of the present dry bean production is in the pinto class. First time dry bean producers should begin with pinto bean because the market is large and this type of bean is easiest to grow with the conventional farm equipment used by lentil growers in

Saskatchewan.

The ideal seeding date is the fourth week of May. Dry bean plants are intolerant of frost at any time. Seeding too early increases the risk of frost for newly emerged seedlings. Seeding too late causes yield and quality loss due to frost in September.

A study of seeding rates showed that seeding to achieve an emerged stand of 30 plants/m^2 was adequate. Row spacing studies showed that 24-inch rows were equal to or better than 12-inch rows under irrigated conditions for dry bean types like pinto and pink which have a viny growth habit. The wide row spacing helps reduce spread of Sclerotinia stem rot which is the main disease problem for irrigated dry bean production in Saskatchewan. Any agronomic practice that slows development of Sclerotinia will increase yield of dry bean.

Harvest date experiments showed that mature dry bean crops do not suffer standing losses due to shattering if stems are not infected with Sclerotinia. The pinto class, in particular, is resistant to shattering loss. The main concern for timing of harvest is combining the crop at 16-18% seed moisture to reduce splitting and cracking.

A harvest method experiment compared direct combining with hand harvesting. Harvest losses ranged form 0-25% but averaged around 10%. Varieties with upright growth habits had lower direct harvest yield losses. Yield losses were reduced for bean types with viny growth habit if Sclerotinia was controlled. Using flex headers and air reels, farmers can keep direct harvest losses to below 10% provided the crop is harvested at the correct time by an experienced operator.

The conclusions of the study were (1) that irrigated dry bean production is possible in the Lake Diefenbaker area of south-central Saskatchewan, and (2) that production is possible using conventional lentil growing technolgy. With good management, irrigation farmers should be able to generate higher net returns from dry bean in comparison to most other irrigated crops. Successful establishment of a dry bean industry will help diversify the types of crops grown under irrigation and provide local employment in processing of the crop. There is potential for the development of 10,000 acres of dry bean production in the Lake Diefenbaker area over the next 5 to 10 years.

2.0 TECHNICAL REPORT

2.1 Abstract

2.2 Background and Objective

Dry bean was grown in Saskatchewan during the 1920s (McGregor, 1931). Results of adaptational trials in the 1920s and 1930s showed that the most promising varieties were in the navy and brown (Scandinavian) market classes (McGregor, 1931; CDA,1934,1938).

In the 1970s, varieties of these and other market classes were evaluated under dryland conditions at the Crop Development Centre in Saskatoon (Slinkard, CDC memos 1972 - 1979). Mean yields in these trials were in the 1300 - 1800 kg/ha range. In 1978 and 1979, adaptational trials were grown under irrigation at Outlook. Yields in the 1800 - 2300 kg/ha range were observed. Highest yields were recorded for the pinto, red mexican and pink market classes.

Based on these preliminary results, a network of demonstration projects was established by irrigation farmers in the South Saskatchewan River Irrigation District No. 1 from 1979 to 1981. By the third year, about 300 acres of dry bean (mostly pinto) were produced. Since then, there has been virtually no production. Farmers were not willing to invest in row cultivation, seeding and harvesting machinery specifically for the dry bean crop. Lack of local marketing options also contributed to the decline of interest in dry bean production.

This research project was initiated with the following objectives:

1) to determine the potential of dry bean as an alternative irrigated crop with emphasis on evaluating various market classes.
2) to identify early-maturing cultivars with high yield potential.
3) to investigate suitable agronomic practices that can optimize yield of irrigated dry bean under Saskatchewan farming conditions, including:
    a) date of seeding,
    b) seeding rate,
    c) row width,
    d) date of harvest, and
    e) harvest method

The goal of the project was to provide enough agronomic and varietal information to form the basis for recommendations for potential Saskatchewan growers. This is essential for the development of a dry bean industry tailored to suit local resources and local farming technology.

2.3 Experimental Methods

Experiments conducted as part of the project are listed in Table 1. All tests located at SIDC were grown under the linear irrigation system on Bradwell sandy loam. In 1988, the U.S. Dry Bean Co-operative Nursery and the Coloured Bean Observational test were grown under a solid set irrigation system on rented land. In 1987 and 1988, seed increases were grown on dryland on the Preston plots in Saskatoon. In 1988, a second location for the Prairie Dry Bean Co-operative Test was grown on dryland at the Kernen farm.

Details of plot size, treatments and experimental design individual experiments are listed in Table 2. All replicated experiments were in randomized complete blocks. The cultivars used in all agronomic experiments are described in Table 3. Viva, UI 111 and Seaforth (or equivalent) were chosen as checks for cultivar evaluations and agronomic evaluations based on their acceptable yield and maturity from previous experiments conducted in Saskatoon and Outlook (CDC memos-1972-1979). Each year, the plot area was treated with trifluralin or ethalfluralin prior to seeding. In 1986 and 1987, plots were irrigated after seeding on May 27 and May 20, respectively. In 1988, the plot area was irrigated prior to seeding on May 20/21.

Post emergent weed control in all three years consisted of spot application of sethoxydim on quackgrass and volunteer cereals plus handweeding for broadleaf weeds. In 1988, plots were treated with benomyl in late July to control Sclerotinia. Irrigation was applied as available or necessary. Target seeding rate for all trials was a post emergent stand of 30 plants/m^2 except in the seeding rate study. Plots were harvested by hand pulling and belt threshing or combining at maturity. For the harvest method study, half the plots were combined directly at maturity with a small plot combine (1986, 1987 - Hege 125B; 1988- Wintersteiger Elite). In 1987 and 1988, seed increases were sown under dryland conditions at Saskatoon in late May.

2.4 Results and Discussion

2.4.1 Cultivar evaluations

The objective of this part of the project was to identify short season but high yielding cultivars of dry bean for possible production in south-central Saskatchewan.

A total of seven cultivar evaluations were grown. The United States Dry Bean Co-operative Nursery, a continent-wide adaptational trial, was grown each year (Tables 4, 5, 6). In each year, some lines in each major market class had acceptable maturity. In 1986, frost in early September damaged most of the late-maturing lines. This contributed to the high variability of yield in this test. All lines matured during the frost-free period in 1987 and 1988. The Saskatoon nursery in 1986 (Table 7) consisted of remnant lines form previous dry bean testing under dryland conditions during the 1970s. Early-maturing lines were favoured due to the relatively early killing frost in 1986. In 1988, three additional trials were grown. Results from the Prairie Dry Bean Co-operative Test (Table 8) and the Pinto Observational Test (Table 9) indicated that at least half the entries had maturity and yield equal to or better than the check varieties Viva (pink), UI 111 (pinto) and Seaforth (navy). These trials were grown under almost ideal conditions for temperature and irrigation in 1988. This is reflected in the high yield compared to 1986 and 1987. In the Coloured Bean Observational Trial, no lines outperformed the check Viva (Table 10).

The Observational Increase plots at Saskatoon in 1987 and 1988 and the Saskatoon location for the Prairie Dry Bean Co-operative Test in 1988 were not harvested. Dry seedbed conditions in 1987 and extreme drought in 1988 resulted in poor establishment, yield and seed quality in both years.

The overall pattern of results from the three year cultivar trials is that ability to mature within the frost-free growing period is the prime consideration for production in south-central Saskatchewan in terms of yield and stability of yield. A dry bean industry can only be established if consistent production is assured. In years with early fall frost, shorter season cultivars yield higher than

late season cultivars.

It is also evident that lines with acceptable maturity for south-central Saskatchewan are available in the major dry bean market classes. Production of the pinto class is initially the most promising because it (1) has the greatest number of potentially adapted cultivars, (2) has the largest market for North American production, and (3) is the easiest to grow with the production technology currently available on Saskatchewan farms. However, the shift to production of other types becomes easier as farmers gain experience. Continued screening of cultivars of all market classes is important in leading the diversification of production within the dry bean market.

2.4.2 Agronomic Investigations

2.4.2.1 Date of seeding

The objective of this study was to identify the ideal seeding date for dry bean production in south-central Saskatchewan. Analysis of climatic data, previous research results, and experience at Brooks, Alberta indicated that seeding prior to May 20 posed unnecessary frost risk for emerging dry bean plants. Accordingly, three seeding dates for each of the check cultivars were seeded at seven to ten day intervals each year commencing on the first possible seeding date beginning May 20.

Results indicate seeding in the fourth week of May is the ideal target seeding date for dry bean production in south-central Saskatchewan (Table 11). In 1986 and 1987, seeding on May 27 resulted in significantly higher yields for all three cultivars compared to first or second week of June seeding dates. In 1988, a year with unusually high temperatures throughout the growing season, there was no significant difference between dates 1 and 2. Date 3 was significantly lower yielding for the pinto and pink bean cultivars in 1988. Seeding dates had no effect on yield of the navy bean cultivar in 1988.

These results clearly indicate that the target seeding date for dry bean should be the fourth week of May. This is similar to the recommended date of seeding for dry bean in southern Alberta. Seeding earlier than the fourth week of May increases the probability of a post-emergent killing frost. Delaying seeding into June, however, increases the risk of significant yield reduction either due to frost in September or due to shifting the growing season into a cooler temperature regime. In terms of temperature and day length, a week in late May represents a larger portion of the potential growing season than a week in early September when days are shorter. The short seeding date window for seeding of dry bean in south-central Saskatchewan reaffirms the importance of seeding only those cultivars that have suitable maturity.

2.4.2.2 Seeding Rate/Row Spacing Study

This study had the objective of identifying the most suitable combination of seeding rate and row spacing for three market classes of dry bean with contrasting growth habits. These were navy (bush or Type I), pink (semi-vine or Type II) and pinto (indeterminate vine or Type III). This is of particular importance in an irrigated production system for dry bean because irrigation can affect crop canopy development.

A combined analysis of variance over years indicated significant effects of year, cultivars and year x row spacing interaction. Yields were highest in 1988 when temperature was above normal and very dry, thus reducing Sclerotinia infection (Table 12). In 1987, yields were depressed because wet cool weather in July and August promoted Sclerotinia infection. Viva significantly outyielded UI 111 in all three years and outyielded D76-125 and Seaforth (navy bean cultivars) in 1987 and 1988, respectively.

Seeding rate had no significant effect on yield of UI 111 in any year (Table 12). The yield of Viva was depressed at the 60 seed/m² rate in both 1987 and 1988. Increased seeding rate had no effect on yield of the navy bean cultivar in 1986 or 1987, but increased yield significantly in 1988. These results are explained on the basis of growth habit and Sclerotinia infection. The indeterminate vine pinto UI 111 produces a full canopy and is susceptible to Sclerotinia at any seeding rate. The semi-determinate vine Viva had consistant yield within years over the 15-45 seeds/m² range. In years with high Sclerotinia infection (1987) or in years when environmental conditions are very favourable (thus promoting inter-plant competition, as in 1988), the 60 seeds/m² rate caused yield reduction.

The relationship between growth habit and Sclerotinia infection is evident by the row spacing x year interaction (Table 13). In years with relatively low pressure from Sclerotinia stem rot (1986 and 1988), row spacing had no effect on yield. In 1987, 60 cm row spacing significantly increased yield compared to 30 cm row spacing for all cultivars, especially for the vining pinto UI 111. These results point out how increased row spacing can be used as a means of reducing Sclerotinia damage in irrigated dry bean production.

2.4.2.3 Harvest Date Study

In south-central Saskatchewan, producers have access to direct harvesting technology used in lentil production. With this system, dry bean crops can be left standing at maturity until harvest conditions are optimal. The objective of this study was to determine the effect of delayed harvesting on yield of bean cultivars in three market classes.

Physiological maturity occurred around September 1 for all three cultivars. Yield data were analysed separately for each

year. There were significant differences in yield among market classes each year (Table 14). The pink cultivar had significantly higher yield compared to pinto in 1986 and compared to navy in both 1987 and 1988. In 1986, the navy cultivar had lower yield on the first date, an indication that it was harvested slightly before physiological maturity. Pinto and pink bean yields were relatively stable across dates.

The 1987 data indicated stable yield across dates for navy and pink but decreasing yield for pinto. The indeterminate vine cultivar UI 111 was severely affected by Sclerotinia in 1987. At maturity, infected stems are weak and brittle. If left standing in the field, yield losses increase as stems collapse due to weathering.

In 1988, delaying harvest did not reduce yield even though winds of greater than 100 km/hr occurred in September. Of the three years, 1988 had the least Sclerotinia infection, partly due to spraying with benomyl.

Unless Sclerotinia infection is a major problem, delayed harvesting will not reduce dry bean yield. In fact, waiting until the grain is at the proper moisture content for combining (16-18%) would be the greatest concern. In most years, the crop could be left standing until frost naturally desiccates the top growth remaining after physiological maturity. Weather records for Outlook from 1952-1988 show that the probability of first frost (natural desiccation) occurring between September 1 and 15 is about 50%. A direct harvesting production system would normally mean combining the crop between September 15 and October 15.

2.4.2.4 Harvest method study

The objective of this experiment was to compare the effect of direct harvesting vs.

hand harvesting on yield of dry bean cultivars representing four distinct growth habits. Three year results are shown in Table 15. Significant yield differences due to cultivar occurred each year but were expected due to differences in adaptation. Results of row spacing comparisons paralleled those of the row spacing study. In general, few differences in yield were observed between 30 cm and 60 cm rows except some cases where narrow rows decreased yield of vine or semi-vine cultivars (combined Viva plots in 1986, 1987) or for some cases where narrow rows increased yield for bush or upright cultivars (Seaforth, Midnight in 1988). The 1986 results for hand pulled navy and black cultivars were considered anomalous because these plots were hand-harvested at maturity when plants were very dry. Pods of these plant types shatter readily when dry and hand harvest actually reduced yields under these conditions.

Yield comparisons between hand pulling and direct combining showed yield reductions for direct combining each year (Table 15). These results, however, are best interpretted in the context of row spacing and growth habit of individual cultivars (Table 16).

In the hand-harvested plots, vine and semi-vine dry bean cultivars grown in 30cm rows yielded only about 90% of what they yielded in 60 cm rows, whereas bush and upright dry bean cultivars grown in 30 cm rows yielded about 104% of what they yielded in 60 cm rows (Table 16). However, in the combine harvested plots vine and semi-vine dry bean cultivars grown in 30 cm rows yielded about 98% of what they yielded in 60 cm rows, whereas bush and upright dry bean cultivars yielded abouat 101% of what they yielded in 60 cm rows. In 30 cm rows the direct combined plots of vine and semi-vine dry bean cultivars yielded only about 78% of the hand harvested plots, whereas direct combined plots of bush and upright dry bean cultivars yielded aboaut

94% of the hand harvested plots. However, in 60 cm rows, the direct combined plots of vine and semi-vine dry bean cultivars yielded about 85% of the hand harvested plots, whereas, direct combined plots of bush and upright bean varieties yielded about 91% of the hand harvested plots.

This points out that direct combining losses are higher for cultivars with vine and semi-vine growth habits. These types are more susceptible to Sclerotinia stem rot infection. Subsequent higher combining losses occur because the infection causes stem collapse leaving pods lower to the ground at harvest. At 60 cm row spacings, the severity of Sclerotinia infection is reduced, thereby reducing direct combining yield losses for vine and semi-vine cultivars. Similar yield loss reductions were not evident when row spacing was increased from 30 cm to 60 cm for bush and upright cultivars. The canopy produced by these types is more open, creating an environment less favourable for Sclerotinia development.

The range of yield loss associated with direct combining compared to hand harvesting was 0 - 25% in this set of experiments. If the comparison were made to the row crop method of undercutting and windrowing, the range would be reduced. Successful direct combining of dry bean with small yield losses can be achieved by a skilled operator if Sclerotinia is controlled.

2.5 Conclusion , Impact and Recommendation

2.5.1 Conclusions

1. Cultivars of suitable maturity are available in most major dry bean market classes.

2. Dry bean crops in south-central Saskatchewan should be seeded the fourth week of May.

3. Sclerotinia stem rot is probably the most serious

threat to irrigated dry bean production in Saskatchewan, but it can be controlled by spraying with registered fungicides.

4. Conventional seeding rates for intended plant populations of 30 plants/m^2 are acceptable for all dry bean market classes.

5. Vine and semi-vine cultivars of dry bean should be sown in 18"-24" rows to help reduce losses due to Sclerotinia stem rot. Bush and upright cultivars can be sown in narrow rows.

6. Dry bean crops can be left standing in the field until mature or killed by frost in September. Standing losses due to shattering are minimal.

   Time of harvest for direct combining should be determined on the basis of seed moisture content (16-18%).

7. Direct harvesting of dry bean with acceptable levels of yield loss is possible for all market classes of dry bean if Sclerotinia stem rot is controlled.

2.5.2 Impact

The results of this project will be instrumental in the development of a dry bean industry in Saskatchewan. Irrigation farmers in the Lake Diefenbaker area will be able to take advantage of their unique microclimate to produce a higher value crop. Local cleaning plants can generate additional revenue from cleaning and processing a new specialty crop. The overall effect will be diversification and strengthening of the local rural economy.

Information generated by this project is already being used. A guide for irrigated dry bean production is being prepared. A successful demonstration project of 35 acres of direct combined irrigated pinto bean production was implemented in 1988 using information gathered through this project. In 1989, several more farmers have applied to participate in demonstrations focussing specifically on Sclerotinia control in irrigated pinto bean production. At least one local cleaning plant is being upgraded to the standard necessary to clean and process pinto bean. Pulse crop marketing companies are expressing interest in contract

production of dry bean in the area. There is potential for development of 10,000 acres of dry bean production in the Lake Diefenbaker irrigation districts in the next 5 to 10 years. The potential farmgate value of this industry is in the range of 3 to 4 million dollars annually.

2.5.3 Recommendations

1. Additional research and development should be conducted on locally adapted methods of Sclerotinia control in dry bean.

2. It is necessary to continue testing of varieties in several market classes because south-central Saskatchewan has a short growing season and therefore has limited potential access to suitably adapted cultivars.

3. Variety testing methods should include those using the direct harvest type of technology available to farmers.

4. In future, the crop insurance program should include coverage for irrigated dry bean production.

5. Local pulse crop cleaners and processors should be encouraged in their effects to upgrade plants to handle dry beans. This will enable them to market high quality product and take on additional contracted production.

3. PAPERS AND TALKS GIVEN

3.1 Papers presented:

A. Vandenberg and A.E. Slinkard, 1988. Evaluation of dry bean as alternative grain and seed production crop for the irrigated regions of south-central Saskatchewan. Proc. Soils and Crops Workshop. Volume 1. February 18-19, University of Saskatchewan.

A. Vandenberg and A.E. Slinkard, 1989. The potential for irrigated dry bean production in Saskatchewan. Proc. Soils and Crops Workshop, February 16-17, University of Saskatchewan.

3.2 Papers in preparation:

Irrigated Pinto Bean Production. Factsheet for SIDC in preparation.

Dry bean production in Saskatchewan. Scientific paper for refereed journal presenting results of 3 year agronomy experiments.

3.3 Oral presentations:

A. Vandenberg. 1989. Dry bean research at SIDC. 13th Annual Pulse Crop Conference, Farm and Home Week. January 10. University of Saskatchewan, Saskatoon.

A. Vandenberg, 1989. Irrigated Specialty Crops Program. Irrigators Seminar. March 1. Saskatchewan Water Corporation, Moose Jaw.

A. Vandenberg, 1989. What's new for irrigated pulses. Irrigation Outlook. March 30. Saskatchewan Water Corporation, Moose Jaw.

4. REFERENCES

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McGregor, 1931. Field beans in Canada. CDA pamphlet No. 141.

Slinkard, A.E. 1971-1979. Crop Development Centre memoranda. University of Saskatchewan.

Table 1. Experiments conducted as part of Project R-86-03-0045.

Year	Description	Location	Number of plots	
1986	U.S. Dry Bean Cooperative Nursery	SIDC	200	
	Saskatoon Nursery	SIDC	88	
	Seeding date study	SIDC	54	
	Seeding rate/row spacing study	SIDC	144	
	Harvest date study	SIDC	90	
	Harvest method study	SIDC	96	672
1987	U.S. Dry Bean Cooperative Nursery	SIDC	128	
	Saskatoon Observational Increase	CDC	30	
	Seeding date study	SIDC	72	
	Seeding rate/row spacing study	SIDC	144	
	Harvest date study	SIDC	90	
	Harvest method study	SIDC	96	560
1988	U.S. Dry Bean Cooperative Nursery	SIDC	128	
	Prairie Dry Bean Cooperative Test	SIDC,CDC	336	
	Pinto Observational Test	SIDC	56	
	Coloured Bean Observational Test	SIDC	84	
	Saskatoon Observational Increase	CDC	70	
	Seeding date study	SIDC	54	
	Seeding rate/row spacing study	SIDC	144	
	Harvest date study	SIDC	60	
	Harvest method study	SIDC	96	1028

SIDC - Saskatchewan Irrigation Development Centre, Outlook, Saskatchewan - irrigated site.

CDC - Crop Development Centre, Department of Crop Science & Plant Ecology, University of Saskatchewan, Saskatoon, Saskatchewan - dryland site.

Table 2. Year, treatments, number of replications, plot size, and row spacing for experiments conducted during Project R-86-03-0045.

Type of experiment	Name of experiment	Year grown	Treatments	No. of reps	Plot size (m)	Rows per plot	Row spacing (cm)	Area harvest (m)
Cultivar evaluation	US Dry Bean Coop Nursery	1986	50 lines	4	1.2 x 3.7	4	30	1.2 X
	US Dry Bean Coop Nursery	1987	32 lines	4	1.2 x 3.7	4	30	1.2 X
	US Dry Bean Coop Nursery	1988	32 lines	4	1.2 x 3.7	3	40	1.2 X
	Saskatoon Nursery	1986	22 lines	4	1.2 x 3.7	4	30	1.2 X
	Pinto Observation Nursery	1987	14 lines	4	1.2 x 3.7	4	30	1.2 X
	Coloured Bean Obs. Nursery	1988	21 lines	4	1.2 x 3.7	3	40	1.2 X
	Prairie Bean Coop Test	1988	42 lines	4	1.2 x 3.7	4	60	1.2 X
Agronomic evaluation	Seeding date study	1986	3 dates, 3 cultivars	6	1.2 x 3.7	4	30	1.2 X
		1987	3 dates, 3 cultivars	6	1.2 x 3.7	4	30	1.2 X
		1988	3 dates, 3 cultivars	6	1.2 x 3.7	4	30	1.2 X
	Harvest date study	1986	5 dates, 3 cultivars	6	1.2 x 3.7	4	30	1.2 X
		1987	5 dates, 3 cultivars	6	1.2 x 3.7	4	30	1.2 X
		1988	5 dates, 3 cultivars	4	1.2 x 3.7	4	30	1.2 X
	Seed rate / row spacing study	1986	15,30,45,50 seeds/m^2 in 30, 60 cm rows for 3 cultivars	6	2.4 x 3.7	4 or 8	30 or 60	1.2 X
		1987	15,30,45,50 seeds/m^2 in 30, 60 cm rows for 3 cultivars	6	2.4 x 3.7	4 or 8	30 or 60	1.2 X
		1988	15,30,45,50 seeds/m^2 in 30, 60 cm rows for 3 cultivars	6	2.4 x 3.7	4 or 8	30 or 60	1.2 X
	Harvest method study	1986	combining, pulling in 30, 60 cm rows for 4 cultivars	6	2.4 x 3.7	4 or 8	30 or 60	1.2 X
		1987	combining, pulling in 30, 60 cm rows for 4 cultivars	6	2.4 x 3.7	4 or 8	30 or 60	1.2 X
		1988	combining, pulling in 30, 60 cm rows for 4 cultivars	6	2.4 x 3.7	4 or 8	30 or 60	1.2 X

Table 3. Characteristics of cultivars used in seeding date, harvest date, seeding rate/row spacing and harvest method studies from 1986-1988

Cultivar†	Market class	Growth habit	Maturity
D76-125	navy	bush	full season
Seaforth	navy	bush	full season
Viva	pink	semi-vine	full season
UI 111	pinto	vine	full season
Midnight	black	upright	late

†D76-125 used in 1986,1987; Seaforth in 1988. Midnight used in harvest method study only.

Table 4. Yield and 1000-seed weight of bean lines in U.S. Dry Bean Co-operative Nursery at Outlook, Saskatchewan, 1986.

Market class	Line or cultivar	Yield (kg/ha)	1000 seed weight (g)
Pinto	UI 114	1407	290
	D84344	917	230
	D81125	993	290
	81-12034	858	330
	D81122	1248	280
	83B229	948	360
	83B235	941	350
	B251	979	330
	81-13197	1206	270
	GH 215	1316	290
	GH 196-2	1060	260
	5323 (4323)	820	300
Pink	45030	1152	210
	4533	1086	260
	USN117	1159	280
	VIVA	1467	230
	B414	1552	260
	B380	917	240
	83B364	1229	270
	ISB459	994	220
	79146	1149	280
Large white or great northern	83B342	1733	280
	83B3 352	1320	280
	83B282	1205	260
	UI 59	775	230
	04020	1146	280
	CB82-11	643	200
	Harris	741	230
Small white or navy	5133 (41010)	1247	140
	Fleetwood	1058	130
	K0125	864	130
	83B17	925	130
	Aurora	1099	110
	UI 158	1409	150
	83B10	927	140
	ISB730	881	160
	83B13	940	130
	83B16	622	140
Red mexican	B103	1300	230
	UI 37	1658	270
Kidney	MRK43	1460	490
	K367	827	410
	Red Kloud	642	510
	K279	638	390
	MRK45	982	470
	Sacramento	1342	600
	Lassen	861	500
	MRK44	1180	600
	K333	843	460
	Linden	994	430
Mean		1073	
CV (%)		31	

Table 3 Seed yield, days to maturity and 1000 seed weight for lines in U.S. Dry Bean Cooperative Nursery at Outlook, Saskatchewan, 1987.

Market class	Line or cultivar	Yield (kg/ha)	1000 seed weight (g)	Days to maturity
Pinto	DB4-340	3477	262	118
	RS101	3065	265	121
	DB4-354	2643	282	122
	UI 114	2581	254	122
	UI 126	2434	233	122
	838235	1718	339	126
Pink	55001	3095	262	118
	Viva	2908	206	114
Large white or great northern	83B-352	2959	257	118
	83B-342	2350	333	126
	UI 59	2004	227	129
	Harris	1678	247	129
Small white or navy	ISB84-244	2675	127	118
	DB1-228	2658	118	125
	ISB82-258	2533	157	116
	Fleetwood	2518	132	124
	Aurora	2486	115	122
	GH-11	2407	150	118
	83B-10	2372	128	122
Kidney	Sacramento	3168	518	114
	57033	2598	482	128
	Montcalm	2576	505	121
	Lassen	2570	488	115
	Red Kloud	2490	531	114
	MRK-45	2472	581	117
	K59	2468	529	123
	MRK-44	2450	523	112
	ISB82-1024	2392	432	117
	MRK-43	2198	511	112
Mean		2502		
CV (%)		18		
LSD (0.05)		673		

Table 6. Yield, seed weight and days to flower and maturity for the U.S. Dry Bean Co-operative Nursery at Outlook, Saskatchevan, 1988.

Market class	Cultivar or line	Yield (kg/ha)	1000 seed weight (g)	Days to flower	Days to maturity
Pinto	Olathe	2098	299	59	114
	ISB84-114	2087	366	54	111
	P86299	2070	329	68	123
	CO-33142	2060	419	60	119
	D85212	1885	291	54	107
	UI 114	1867	316	59	116
	8173-6E	1856	311	53	106
	D85234	1743	258	61	113
	RS101	1733	303	59	110
	ISB82-354	1527	370	51	103
Pink	Yolano	2162	316	57	109
	UNS-117	2029	297	58	110
	Viva	2015	227	54	108
Large white or great northern	64043	1994	297	69	125
	UI 59	1965	298	68	122
	JM24	1789	293	65	122
	GN-WM-85-55	1747	308	68	125
	GN-WM-85-45	1577	389	56	119
	GN-WM-85-43	1468	370	60	117
Small white or navy	6137	1677	161	56	118
	Aurora	1532	130	60	120
	Fleetwood	1420	168	62	123
	ISB82-258	1367	169	62	117
	Mayflower	1202	161	66	122
	6123	962	144	61	119
Kidney	Red Kloud			51	
	Montcalm			62	
	K-59			65	
	K-407			68	
	Lassen			52	
	Lisa			67	
	ISB82-1024			61	
Mean		1752			
CV (%)		14			
LSD (0.05)		354			

Table 7. Yield and seed weight of lines in the Saskatoon Dry Bean Nursery at Outlook, Saskatchewan, 1986.

Market class	Line or cultivar	Yield (kg/ha)	1000 seed weight (g)
Pinto	Agate	928	260
	UI 111	830	280
Pink	Viva	1089	190
Great northern or large white	Coco	1354	450
Small white or navy	Seafarer	1026	160
	79-23	1457	400
	Ex Rico	781	150
	Swan Valley	393	120
Red mexican	D79-144	1007	260
	Garnet	977	210
	UI 36	780	220
	NW 63	927	250
Black	Midnight	916	130
	Black Magic	553	120
	Midnight	773	140
Other	79-33	1648	370
	Dwarf Horticultural	1373	520
	Munhall	1352	460
	Red peanut	1288	170
	Vermont cranberry	1107	350
	T81-01	1021	130
	Steuben	833	330
Mean		1018	
CV (%)		21	

Table 8. Mean yield, seed weight, days to flowering and days to maturity for Prairie Bean Coop Test at Outlook, Saskatchewan, 1988.

Market class	Cultivar or line	Yield (kg/ha)	1000 seed weight (g)	Days to 50% flower	Days to maturity
Pinto	Nodak	5006	335	46	105
	Othello	4871	374	45	110
	Norwest590	4779	328	48	112
	Topaz	4513	373	47	105
	Fiesta	4456	426	47	108
	UI 114	4350	381	54	116
	UI 111	4231	384	52	113
	Norwest410	4160	322	56	118
Pink	55001	5043	309	46	113
	ISB473	5028	310	45	98
	Harold	4725	330	46	115
	Viva	4402	279	47	113
Large white or great northern	US-1140	4620	336	42	115
	83B342	4407	401	48	116
	83B352	4320	330	48	105
Small white or navy	Pulsar	3956	176	44	100
	K0107	3883	176	49	113
	L-9336	3690	178	55	117
	D80024	3611	196	48	104
	ISB274	3411	177	47	117
	L-9322	3381	199	51	115
	Upland	3344	194	45	104
	L-9325	3320	188	50	115
	L-9384	3317	198	50	116
	HR14	3300	222	51	101
	D84071	3194	183	44	117
	L-9340	3128	207	55	115
	B2W83-3	2998	201	44	105
	ISB85-486	2953	179	43	110
	ISB1	2940	205	47	104
	OAC Seaforth	2899	208	45	104
	ISB82-258	2450	193	50	111
Red mexican	ISB480	5197	318	46	100
	NW63	5086	345	45	116
	Garnet	4729	299	43	105
	UI36	4504	356	44	114
	D79144	4384	368	44	97
	Rufus	3513	306	52	119
Kidney	Red Kloud	3824	538	43	116
	Montcalm	2961	561	48	--
Black	MDA075067	3387	198	53	114
	Loop	3367	186	55	109
Mean		3941			
CV (%)		11			
LSD (0.05)		583			

Table 9. Mean yield, seed weight, plant height, days to flower and days to maturity for Pinto Observational Test, at Outlook, Saskatchewan, 1988

Cultivar or line	Yield (kg/ha)	1000 seed weight (g)	Plant height (cm)	Days to maturity	Days to flowering
NW590	5110	335	27	116	52
Topaz	4961	404	30	115	52
Olathe	4879	381	29	116	51
Fiesta	4740	401	33	107	48
81125	4736	397	29	115	52
Bill Z	4620	344	27	110	50
NW410	4462	364	26	118	54
Pindak	4413	316	29	109	53
Othello	4123	360	29	105	49
UI 111	3968	348	34	104	49
Nodak	3777	331	24	103	48
6315	3462	376	32	103	48
5325	3370	366	29	103	49
Ouray	3225	432	31	120	54
Mean	4275				
CV (%)	13				
LSD (0.05)	772				

Table 10. Mean yield, seed weight and days to maturity for Colored Bean Observational Test at Outlook, Saskatchewan, 1988

Market class	Cultivar or line	Yield (kg/ha)	1000 seed weight (g)	Days to maturity
Pink	Viva	3127	250	112
	55009	2423	294	107
	5524	2326	293	105
	5521	2326	293	105
	55038	1859	315	110
Large white	54026	2569	333	110
	54038	2493	297	115
	85:598	2432	272	105
	UI 59	2269	325	123
	5430	2155	335	119
Small white	6138	2344	160	113
	6137	1805	179	119
	Seaforth	1376	196	122
	Seaforth	1246	192	111
	6123	1037	166	113
	6124	704	171	117
Red	5217	2731	293	105
	52024	2288	282	101
	52059	2106	262	101
	52009	1799	306	107
Black	UI 906	1448	161	111
Mean		2031		
CV (%)		18		
LSD (0.05)		504		

Table 11. Effect of seeding date on seed yield of three dry bean cultivars grown at Outlook, Saskatchewan, 1986-1988

Year	Market class	Cultivar	Seeding date 1	2	3	Mean
			kg/ha			
1986			(May 27)	(June 3)	(June 10)	
	Pinto	UI 111	2172	1526	1334	1677
	Pink	Viva	3015	2048	1572	2212
	Navy	D76-125	2425	1434	809	1556
	Mean		2537	1669	1238	
	Pooled SE					149
	CV (%)					14
1987			(May 27)	(June 3)	(June 10)	
	Pinto	UI 111	2630	1912	661	1734
	Pink	Viva	2844	2269	895	2003
	Navy	D76-125	2201	1454	400	1351
	Mean		2558	1878	652	
	Pooled SE					199
	CV (%)					18
1988			(May 21)	(June 1)	(June 9)	
	Pinto	UI 111	2692	3174	2283	2716
	Pink	Viva	2867	3130	2448	2815
	Navy	D76-125	1250	1209	1182	1214
	Mean		2270	2504	1971	
	Pooled SE					281
	CV (%)					22

Table 12. Effect of seeding date on seed yield of three dry bean cultivars grown at Outlook, Saskatchewan, 1986-1988

Year	Market class	Cultivar	Seeding rate (seeds/m²)* 15	30	45	60	Mean
			kg/ha				
1986	Pinto	UI 111	2445	2355	2272	2313	2346
	Pink	Viva	2935	2938	3063	2684	2906
	Navy	D76-125	2309	2592	2700	2550	2538
	Mean		2563	2629	2678	2515	
	Pooled SE						208
	CV (%)						20
1987	Pinto	UI 111	1745	1669	1441	1511	1592
	Pink	Viva	2625	2521	2364	2261	2443
	Navy	D76-125	1810	1890	1933	1659	1823
	Mean		2060	2027	1912	1810	
	Pooled SE						147
	CV (%)						20
1988	Pinto	UI 111	3286	3002	3003	3048	3084
	Pink	Viva	3975	4038	4042	3463	3880
	Navy	D76-125	2587	2912	3322	3323	3036
	Mean		3283	3317	3456	3278	
	Pooled SE**						228
	CV (%)						17

* Yield values are means of 6 replicates over 2 row spacings.

** Pooled estimate of standard error.

Table 13. Effect of row spacing on yield of three dry bean cultivars grown at Outlook, Saskatchewan, 1986-1988.

Year	Market class	Cultivar	Row spacing (cm)* 30	60	Mean
			kg/ha		
1986	Pinto	UI 111	2400	2563	2346
	Pink	Viva	2852	2952	2905
	Navy	D76-125	2512	2563	2536
	Mean		2590	2603	
	Pooled SE				147
	CV (%)				20
1987	Pinto	UI 111	1341	1842	1592
	Pink	Viva	2161	2724	2443
	Navy	D76-125	1660	1986	1823
	Mean		1721	2184	
	Pooled SE				104
	CV (%)				18
1988	Pinto	UI 111	3218	2952	3084
	Pink	Viva	3932	3828	3880
	Navy	D76-125	3107	2965	3036
	Mean		3419	3248	
	Pooled SE**				162
	CV (%)				17

* Yield values are means of 6 replicates over 4 seeding rates.

** Pooled estimate of standard error.

Table 14. Effect of harvest date on mean seed yield of three dry bean market classes at Outlook, Saskatchewan, 1986-1988.

Year	Harvest[a] date	Market class			Mean
		Navy	Pinto	Pink	
		kg/ha			
1986	1	776	846	1290	971 a[b]
	2	1136	898	1251	1095 b
	3	1172	939	1303	1138 b
	4	1179	1038	1271	1163 b
	5	1107	978	1098	1061 ab
	Mean	1072	941	1241	
	LSD (0.05)	(MCxHD)		223	
	CV (%)				16
1987	1	1620	1741	2290	1917 b
	2	1569	2064	2117	1917 b
	3	1302	1822	1885	1670 ab
	4	1166	1467	1949	1527 a
	5	1552	1325	2233	1703 ab
	Mean	1441	1684	2115	
	LSD (0.05)	(MC)		446	
	CV (%)				22
1988	1	2891	4736	4968	4198 a
	2	3070	4247	3880	3732 a
	3	2882	4449	5067	4133 a
	4	2487	5044	4399	3977 a
	5	2938	3564	4602	3701 a
	Mean	2862	4408	4620	
	LSD (0.05)	(MC)		843	
	CV (%)				16

[a] Harvest dates: Plots were bagged and combined when dry. Date 1 represents physiological maturity. Subsequent dates are weekly intervals thereafter.

[b] Mean yield for dates within years followed by same letter are not significantly different by LSD test at P = 0.05 level.

Table 15. Effect of harvest method and row spacing on seed yield of four dry bean cultivars grown at Outlook, Saskatchewan, 1986-1988

Year	Market class	Cultivar	Hand harvested		Combined		Market class mean
			15	30	45	60	
			kg/ha				
1986	Pinto	UI 111	1465	1699	1441	1564	1542
	Pink	Viva	1526	1566	1201	1613	1477
	Navy	D76-125	846	1174	868	904	948
	Black	Midnight	656	1293	875	977	950
	Mean		1123	1433	1096	1264	
	Pooled SE		125		134		
	CV (%)		18		18		
1987	Pinto	UI 111	2241	2153	1882	1940	2054
	Pink	Viva	3260	3212	2546	3022	3010
	Navy	D76-125	2095	1971	1808	1878	1938
	Black	Midnight	2145	2134	2136	1892	2097
	Mean		2435	2367	2093	2183	
	Pooled SE		160		144		
	CV (%)		10		13		
1988	Pinto	UI 111	4164	4171	2886	3190	3603
	Pink	Viva	4360	4592	3386	3494	3958
	Navy	D76-125	2761	2294	2582	2425	2475
	Black	Midnight	3953	3537	3461	3156	3526
	Mean		4019	3707	3079	3066	
	Pooled SE[a]		200		214		
	CV (%)		8		12		

[a] Pooled estimate of standard error.

Table 16. Percentage comparisons of relative mean yield of harvest method and row spacing treatments for four dry bean cultivars grown at Outlook, Saskatchewan, 1986-1988

Market class	Cultivar	Growth habit	Yield in 30 cm rows as % of yield in 60 cm rows for hand harvested plots	Yield in 30 cm rows as % of yield in 60 cm rows for combine harvested plots	Yield of combined plots as % of yield of hand harvested plots in 30 cm rows	Yield of combined plots as % of yield of hand harvested plots in 60 cm rows
Pinto	UI 111	vine	92.7	98.1	78.9	83.4
Pink	Viva	semi-vine	87.7	97.6	78.0	86.8
Navy	D76-125	bush	101.0	104.9	92.2	95.8
Black	Midnight	upright	107.4	97.0	95.8	86.5